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Evaluation of Berseem in Relay Cropping with Mustard as a Viable Climate Resilience Technology for Income Enhancement in semi-arid tropics Areas

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Abstract— *Trifolium alexandrinum, commonly known as Berseem is the main legume fodder cultivated in the south-east Asia because of its more vegetative growth, multi-cut nature, better forage output after harvesting, prolonged time of forage provision, and prominent fodder yield with outstanding delicious and excessive beneficial values of 20-21% crude protein and 62% total edible food. The livestock is contributing up to 40 % of total annual income of small and marginal farmers of district. However, there was significant scarcity of green fodder during lean period. To increase the green fodder availability with increase in net farm income present study was undertaken to evaluate the berseem in relay cropping with mustard crop at farmers field in NICRA project at KVK Morena. The results revealed that the crop of berseem grown as relay cropping with mustard is shown higher net return and B:C ratio compared as sole crop of mustard or berseem. As per our findings, the mustard crop establishment and relay cropping with legume crop berseem with mustard have overall beneficial and wide scope for its adoption in similar agro-ecological circumstances under present changing climate condition.*

Keywords— ***Relay cropping, Berseem, Mustard, Farm Income and Climate***

I. INTRODUCTION

Trifolium alexandrinum, commonly known as Berseem is the main legume fodder cultivated in the south-east Asia because of its more vegetative growth, multi-cut nature, better forage output after harvesting, prolonged time of forage provision, and prominent fodder yield with outstanding delicious and excessive beneficial values of 20-21% crude protein and 62% total edible food (**Yadav et al., 2015**). This leguminous crop holds significant agricultural importance, particularly as a winter crop in Madhya Pradesh. Berseem Clover was introduced into northern India in the early 19th century and has found it's place in various regions globally, including the United States, Europe, China, and Australia. Berseem clover typically grows between 30 to 100 cm height, featuring erect or ascending stems. It is used as green forage during the season as well as hay or pallets during off season (**Nigam et al., 2010**). Moreover, it serves as an effective fodder crop, suppressing weeds and enriching the soil with nitrogen, providing up to 280 lbs/acre to subsequent crops (). India occupies the largest berseem growing area (2 m ha) followed by Egypt (1.1 m ha) and Pakistan (0.71 m ha) (**Muhammad et al., 2014**).

The inclusion of berseem into cropping systems presents opportunities for enhancing yield and income, particularly in mustard-based cropping systems. Recent studies showed that berseem can also be used for phytoremediation of heavy metals viz., Cd, Pb, Cu and Zn, due to its multi-cut nature, short life cycle and production of considerable biomass (**Ali et al., 2012**). The potential effect of cover crops on soil water conservation is especially significant because of the documented impact of soil water

on crop yield, especially for dry land cropping systems (**Acharya, *et al.* 2019**). The fodder and seed yield from improved varieties is significantly higher as compared to those as obtained by small holder farmers (**Govt. of the Punjab, 2014**).

In oilseed crops, Indian mustard (*Brassica juncea*) is second most important oilseed crop grown with fellow/pearl millet/cluster bean/green gram/black gram-based cropping systems. These cropping systems are grown in limited irrigated areas with intensive tillage, improper crop establishing and imbalanced use of chemical fertilizers (**Singh, 2023**). Mustard-based cropping systems have been experiencing a decline in productivity, economic profitability and soil quality in India's arid and semi-arid climate. Crop residues burning and imbalanced utilization of chemical fertilizers resulted in deteriorating soil quality and resources; are some of the factors contributing to the declining performance of mustard crop (**Fustec et al., 2010**). In gird region of Madhya Pradesh, fellow- mustard or pearl millet – mustard cropping system is mostly in practice. Among the oilseeds in India, Brassica ranks second in production (2015-16) after soybean (**GOI, 2017**).

Animals are the most important part of farming system in Morena district of Madhya Pradesh and it contributes approximately forty percent (40%) in annual income of small and marginal farmers. Livestock are indispensable for production of milk & meat and for work provisions (**Anwar et al., 2012**). Small & marginal farmers may have limited opportunities to cultivate green fodder, particularly during the lean season, where owning livestock is an alternate income generator (**Sahu and Jha, 2022**).

In this context, the current investigation aimed to investigate the impact of relay cropping of legume crop berseem with mustard-based cropping systems on the productivity of crops (mustard and berseem), yield attributes and economic parameters.

II. MATERIALS AND METHOD

Field experiments were conducted in two successive years *i.e.,* 2023-24 and 2024-25 at on-farm locations *viz*., Kolua and Khargpura villages of Ambah Block of Morena district of Madhya Pradesh under the National Innovation on Climate Resilience Technology (NICRA) project. The study location has a semi-arid climate, severely cold from Dec to Jan (0°C minimum temp.), and hot from May to June (48°C maximum temp.). The weekly mean of the minimum and maximum relative humidity ranged between 23.3-88.0% and 38.1-90.4%, respectively. The mean annual rainfall was 650 to 750 mm, mainly received in July and Aug months. At the time of the investigation, the minimum and maximum temperature were 2°C and 47°C, correspondingly. The total annual rainfall received was 942.5 and 848 mm during the year 2023-24 and 2024-25, respectively. The soils of selected fields were sandy loam with the texture of an old alluvial plain.

The spacing between row-to-row for mustard were kept 30 cm and 4.0 kg seed /ha was used for sowing. At 35-40 days after sowing (DAS) of mustard, berseem (Var.- Bundel Berseem -3) were sown uniformly by applying broadcasting @ 20.0 kg^{-1} ha just prior to the first irrigation given to mustard. The seed treatment of berseem was done with captan (2.0 g/ kg seed) followed by *Rhizobium trifoli* and *Pseudomonas fluorescens*. A recommended agronomical package of practices was adhered to raise the experimental crops. The total plot area 4000 m^2 was divided into two equal parts. Each intervention had ten locations, with and without relayed berseem was established. Five locations were selected and every location was treated as a replication for statistical analysis in Randomized Block design.

As per recommendations for mustard crop, the full recommended dose of P, K, S and Zn was 50, 30, 40 and 5 kg ha^{-1} applied at time of sowing, while N was applied in two splits of 50 kg ha^{-1} at time of sowing and the remaining 50 kg^{-1} ha at tine of flower initiation (about 40 DAS). The berseem was grown in residual nutrition of mustard. The mustard crop was harvested in the first week of March of each year. After the harvesting of mustard, three irrigations were given to the berseem crop after harvesting of mustard, at head formation and seed filling stages. Spinosad @ 150 ml ha^{-1} was applied to control pod borer (*Helicoverpa armigera*), at the economic threshold level in berseem. The berseem crop was harvested during 3rd to 4th week of may. The crop yield was recorded for individuals grown in the systems.

Seed and straw yield, gross and net returns and benefit cost ratio were calculated. The economics of the crops between the sowing and harvest of crops were examined. The system productivity of different crops was calculated with the yields of non-mustard crops converted into mustard equivalent yield (MEY) for berseem, as advised by **Singh et al. (2020**).

$$\text{MEY (t ha)} = \frac{\text{Berseem seed yield (q ha}^{-1}) \times \text{Prevailed Market price of Berseem (q\^(}-1)}{\text{The minimum support price of mustard (q\^(}-1))}$$

III. RESULTS AND DISCUSSION

The yield of mustard crop was increased under relay cropping system in comparison to sole crop while the berseem yield showed slight deterioration under relay cropping (Table1). However, total output as mustard equivalent yield of relay cropping is higher than both sole crops under demonstrated fields (Table 2). The mustard equivalent yield was comparably higher than sole crop of both crops grown individually during both the years at all locations of farmer's field. The yield of any crop plant depends upon the source sink relationship and is the cumulative function of various growth parameters and yield attributing components of sink viz. growth and dry matter content etc (**Kumar et al. 2024**). Under this situation, two crops of different root-shoot growing nature are grown at a certain proportion. Thereby increases the cropping intensity, total productivity and profitability under efficient utilization of soil, water, nutrients and sunlight in time and space (**Panday et al. 2021**)

Almost all observed yield attributes *i.e.*, plant height at harvest (cm), numbers of siliquae or pod per plant and numbers of seeds per siliquae or pod were also comparable in both crops as sole and relay crop (Table1). According to **Singh et al. (2024),** leguminous crop berseem is known to ameliorate soil quality over the years, contributing to system productivity. Likewise, **Singh et al. (2020)** reported that the relay berseem with mustard significantly enhanced the soil quality and system productivity.

The cost of cultivation for relay cropping was higher than sole crops while the net return Rs.84490/ha was also reported higher than sole crops of mustard and berseem Rs. 64882/ha and Rs. 4732/ha respectively. The higher net returns with berseem relay cropping with mustard probably due to improved soil fertility resulted in a higher yield of crops and additional net income (**Singh et al. 2024**).

Table1: Yield and its attributes of mustard and berseem crop as affected under different production systems (Mean of two successive years i.e., 2023-24 & 2024-25)

Treatment	Yield (q/ha)	Straw yield (q/ha)	Plant height at harvest (cm)	Numbers of siliquae or pod/plant	Numbers of seeds/ siliquae/ pod
Berseem (Sole crop)	04.50	6.25	072.50	25	6.3
Mustard (Sole crop)	19.33	25.63	187.30	230	5.5
Mustard + Berseem (relay cop)	20.65 (03.94)	24.54 (5.32)	184.00 (074.09)	232 (22.4)	4.7 (4.5)

Note : Value of berseem in parenthesis

Table 2: Yield and economics of mustard & berseem as sole crop and with relay cropping (Mean of two successive years i.e., 2023-24 & 2024-25)

Treatment	MEY (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C Ratio
Berseem (Sole crop)	7.09	33500	38232	4732	1.14
Mustard (Sole crop)	19.33	39500	104382	64882	2.64
Mustard + Berseem (relay cop)	26.85	60500	144990	84490	2.39
SEm +_	**0.087**	**NA**	**NA**	**NA**	**NA**
CD@5%	**0.253**	**NA**	**NA**	**NA**	**NA**

IV. CONCLUSION

The results revealed that the crop of berseem grown as relay cropping with mustard is shown higher net return and B:C ratio compared as sole crop of mustard or berseem. As per our findings, the mustard crop establishment and relay cropping with legume crop berseem with mustard have overall beneficial and wide scope for its adoption in similar agro-ecological circumstances under present changing climate condition.

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